Environment, Energy, and Economic Development

A RAND INFRASTRUCTURE, SAFETY, AND ENVIRONMENT PROGRAM

Evaluating Climate Adaptation Strategies in the Sierra Nevada Using Probabilistic and Robust Decisionmaking Methods

A Report on Work in Progress

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Outline

- **Project Motivation**
- **Case Study Description**
- **Project Components**
- **Data, Tools, and Approach**

Water Agencies Need Improved Analytic Approaches to Develop Climate Adaptation Strategies

- **Historical hydrologic conditions may not be representative of future conditions**
- **Climate change impacts on water systems are varied and deeply uncertain**
- **Traditional water supply augmentation options are limited**

Study Demonstrates New Approaches for Developing Climate Adaptation Strategies in the Water Sector

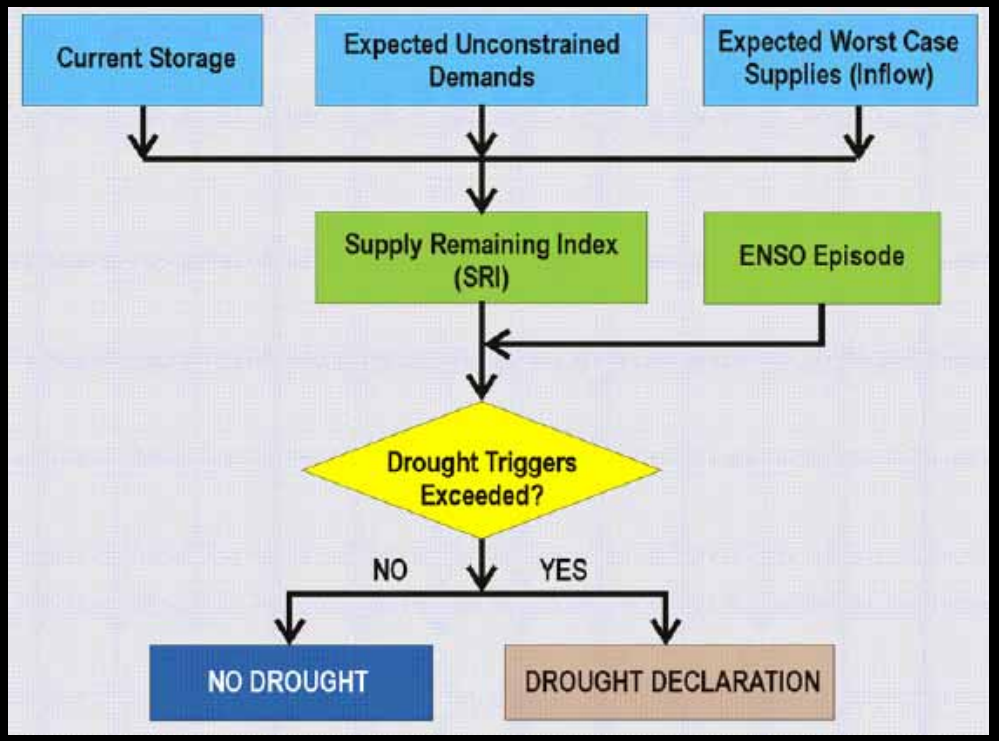
- **Historical hydrologic conditions may not be representative of future conditions**
  - ➢ **Consider other plausible hydrologic sequences reflecting climate change**
- **Climate change impacts on water systems are varied and deeply uncertain**
  - ➢ **Evaluate wide range of threats (e.g. fire risk)**
  - ➢ **Seek *robust* rather than *optimal* strategies**
- **Traditional water supply augmentation options are limited**
  - ➢ **Systematically explore wide range of integrated options and implementation schedules**

Case Study Evaluates Climate Adaptation Options for El Dorado Irrigation District (EID)

- **Serves ~ 100,000 people over 200 sq. mi service area**
- **Surface supplies from SF American and NF Cosumnes Rivers and tributaries**
- **Demand projected to grow 87% from 2005 to 2030**
- **Changes in Sierra snow pack and precipitation could reduce supply**
- **Other important factors:**
  - **Fire in watersheds**
  - **Meeting minimum flow requirements**
  - **Hydropower generation**

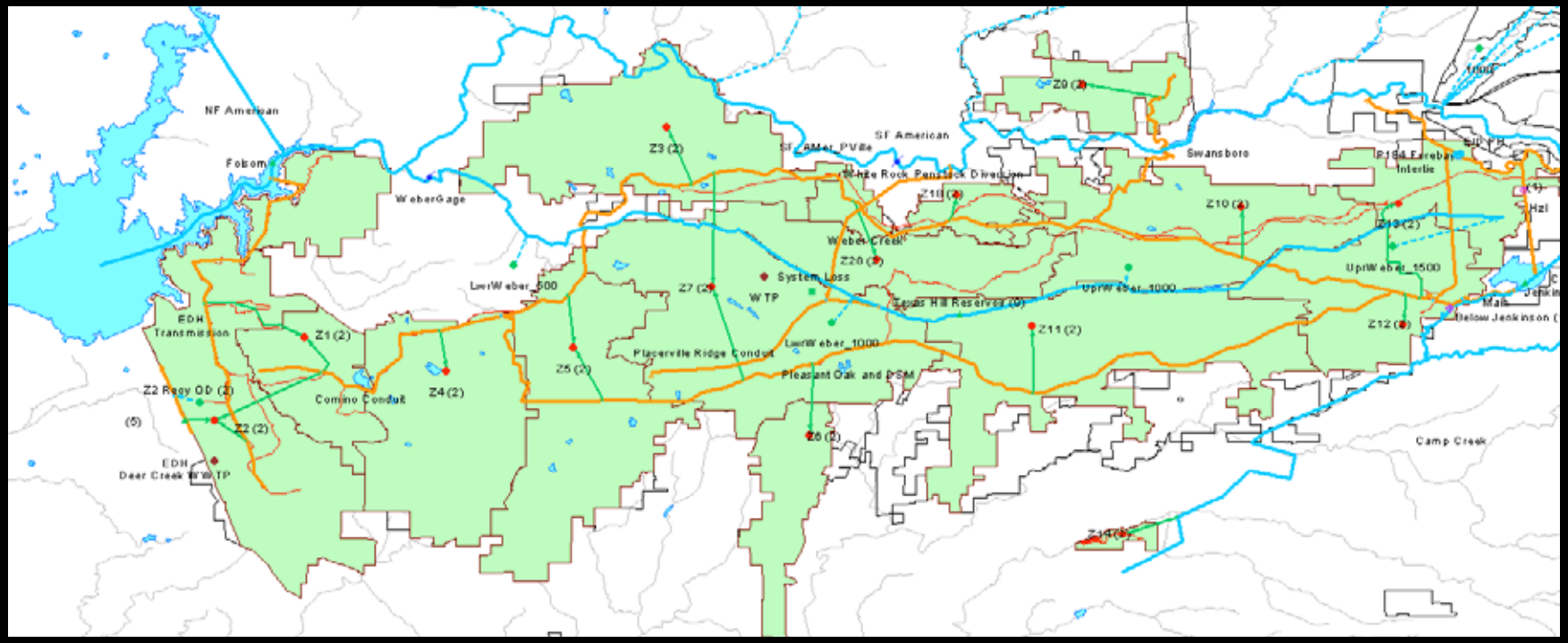
Previous Studies Have Begun to Address Hydrologic Uncertainty in Planning

- **Shared Vision Model developed to optimize Drought Management Plan**
- **Drought triggers determined under 2010 demands and historical hydrology**



***Drought Preparedness Plan For El Dorado Irrigation District*, Brown and Caldwell, 2009**

Hydrologic Model Developed to Evaluate Drought Management Plan Under Climate Change



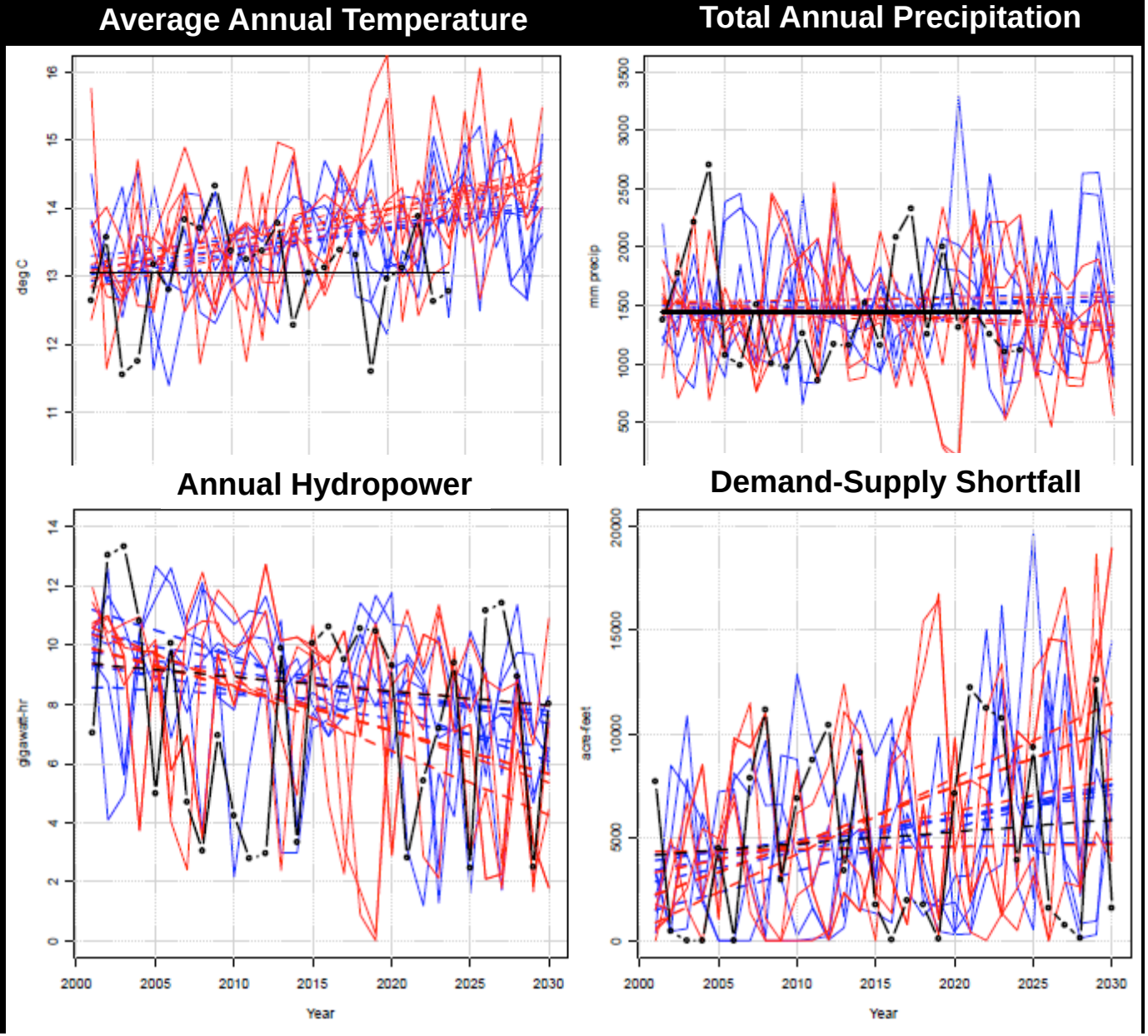
- **Water Evaluation And Planning (WEAP)**

- **34 catchment objects**
- **15 demand sites**
- **9 reservoir objects**
- **Major transmission facilities**

***A Physically-Based Approach to Drought Planning and Climate Change for the EID*, Stockholm Environment Institute, 2009**

Drought Plan Shown to Be More Vulnerable Under Non-Historic Hydrologic Conditions

- **Black line:** Historical (1980-2003)
- **Red lines:** 5 synthetic climate sequences
- **Blue lines:** 5 synthetic climate sequences



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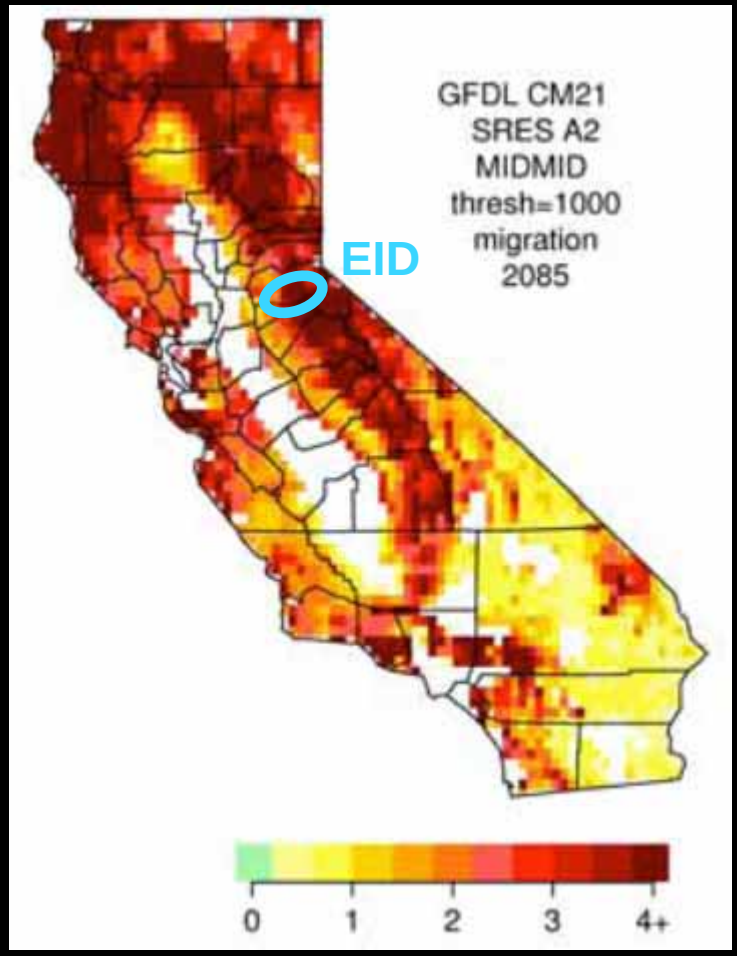
PIER Project Will Expand WEAP Model of EID

1. **Evaluate CEC climate change scenarios**
2. **Include price-sensitive water demand functions**
   (developed by UC Berkeley researchers under NOAA grant)
3. **Include fire risk into assessment**
4. **Develop innovative scenario visualizations through integration with Google Earth**
5. **Evaluate static and evolving adaptation options**

Climate Change May Lead to Changes in Watersheds Fire Frequency and Extent

- **Estimated probability of *large* (>200 ha) and *very large* wild fires (>8500 ha)**
  - **Land-surface characteristics**
  - **Human population**
  - **Climate**
  - **Migration of ecosystems & fire regimes**
- **Spatial and temporal resolution**
  - **1/8th deg (~12 km) grid**
  - **30-year periods around 2020, 2050, and 2080**



Burned Area as Multiple of Reference Period

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Climate Change, Growth, and California Wildfire, Westerling et al., 2009

WEAP Model Modified to Reflect Fire Impacts on EID Watersheds

Key Fire Characteristics

- Frequency
- Spatial extent
- Severity
- Intensity

Relationships under development

WEAP Hydrologic Parameters Affecting Runoff

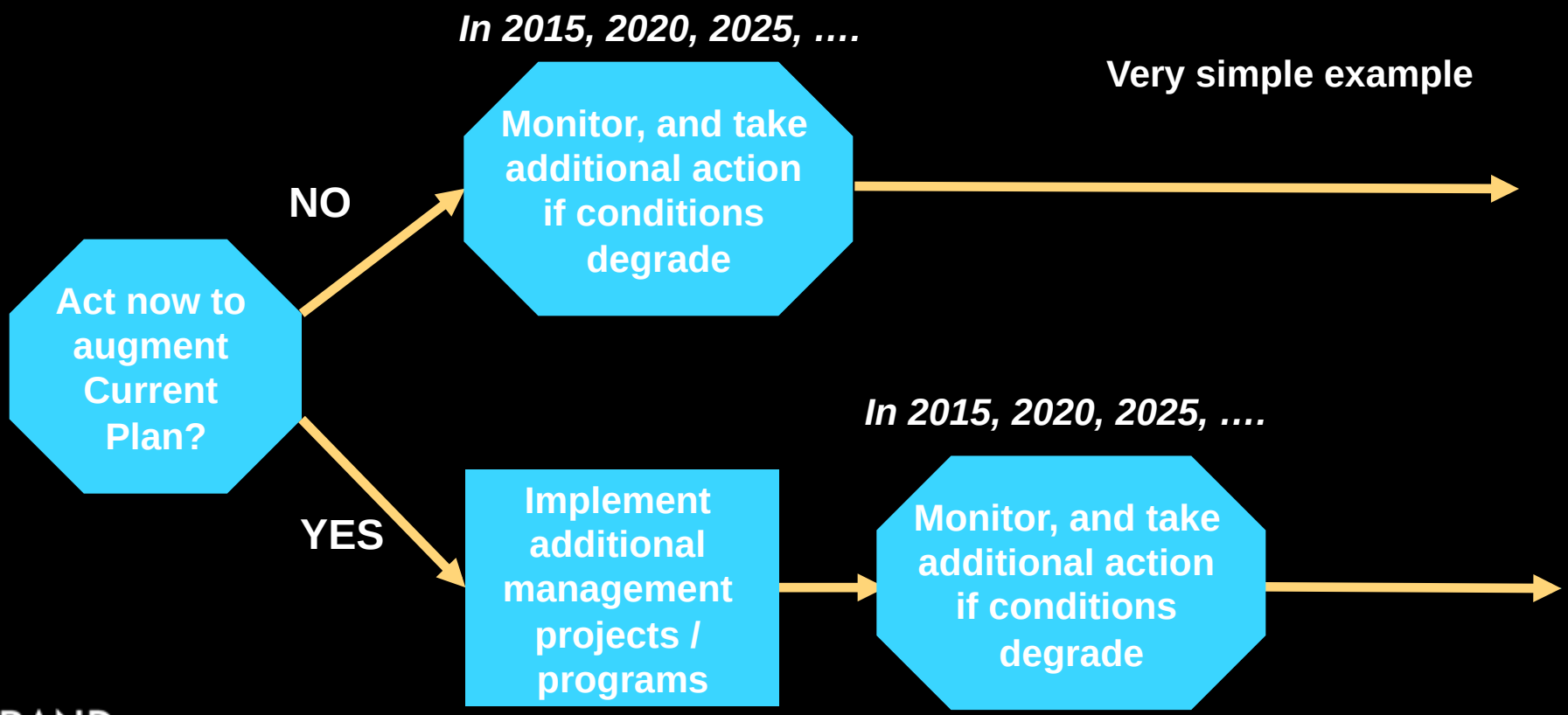
- Reference crop coefficients (*K*)
- Flow direction (*f*)

Study Will Evaluate Different Water Management Strategies for EID

- **Strategies comprised of individual projects/programs:**
  - **New reservoirs**
  - **Expanded treated wastewater distribution and use**
  - **Groundwater banking**
  - **Storage agreements**
  - **Water transfers**
  - **Conservation / efficiency (pricing & programs)**

Study Will Explicitly Model Adaptive Strategies

1. **Near-term actions**
2. **Sign-posts**
3. **Hedging actions**



EID Strategies Will Be Evaluated Many Times Under Different Future Scenarios

- **Scenario Factors:**
  - Climate conditions
  - Demographic changes
  - Fire risk precursors
  - Demand response to water price
  - Environmental regulations
  - Management costs
- **Performance metrics:**
  - Water supply reliability
  - Environmental performance
  - Cost
  - Others….

Scenarios Will Inform Strategy Choice Using Two Methods

- **Probabilistic Assessment**
  - **Apply weights to each scenario to yield probabilistically-derived ranking of strategies**
- **Robust Decisionmaking**
  - **Identify key vulnerabilities to promising strategies**
  - **Define hedging actions that alleviate key vulnerabilities**
  - **Iterate and present tradeoffs to policymakers and/or stakeholders**

Study Will Be Integrated Into 2010 Urban Water Management Plan (UWMP) Process

- **Stakeholders and EID board members to provide input**
  - **Key uncertain factors**
  - **Performance metrics**
  - **Hedging options, adaptivity features**
- **Analysis to augment state-mandated UWMP analyses**
- **Project to illustrate approach for other water agencies**

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